NASA STTR 2010 Phase I Solicitation

T1 Rocket Propulsion/Energy Conservation

The Small Probe Entry Descent and Landing System topic seeks proposals in relevant technology areas that will enable low cost approaches to obtaining flight data and qualify thermal protection systems in mid TRL levels and/or using small probe as a way to conduct bio, space and materials science experiments in space and bring back samples for laboratory analysis. The Information Technologies for Intelligent Planetary Robotics subtopic seeks proposals to develop information technologies that enable planetary robots to better support human exploration, with robotic support for human tasks such as advance scouting, site surveys, and site prep and documentation tasks that will enable long-duration missions.

Subtopics

T1.01 Small Probe Entry Descent and Landing Systems

Lead Center: ARC

The Entry, Descent and Landing (EDL) system of a spacecraft allows the payload to enter the atmosphere, survive the heating pulse, and touch down in a manner that doesn't harm the payload. The system generally consists initially of a spacecraft bus and an entry probe. The entry probe contains the payload.

During the initial entry portion of the mission the spacecraft bus provides power, avionics and maneuvering that governs the entry angle and a small de-orbit burn that sets the payload on the desired trajectory. This portion of the spacecraft is generally jettisoned before entry and is burned up in the atmosphere.

The Thermal Protection System (TPS) protects the payload from the severe heating encountered during hypersonic flight through a planetary atmosphere. In general, there are two classes of TPS: reusable and ablative. Typically, reusable TPS applications are limited to relatively mild entry environments like that of Space Shuttle. No change in the mass or properties of the TPS material results from entry with a significant amount of energy being re-radiated from the heated surface and the remainder conducted into the TPS material. Typically, a surface coating with high emissivity (to maximize the amount of energy re-radiated) and with low surface catalycity (to minimize convective heating by suppressing surface recombination of dissociated boundary layer species) is employed. The primary insulation has low thermal conductivity to minimize the mass of material required to insulate the primary structure. Ablative TPS materials, in contrast, accommodate high heating rates and heat loads through phase change and mass loss. All NASA planetary entry probes to date have used ablative TPS.

The payload contained in the thermal protection system may have special system constraints that will govern the design of the probe, such as peak deceleration loads and thermal control. For example a biological sample returning from space station may be limited to a few g's and max temperature rise on the order of 25 deg C.

The final portion of the entry is the landing system, typically defined as occurring during the supersonic and subsonic portions of the entry. The final touchdown can be via parachute or by direct impact of the probe with the planetary surface. While the parachute system adds mass and complexity to the mission it provides a final touchdown velocity small enough not to damage the probe. If the goal of the mission is to recover the probe without any impact damage the parachute and probe system can be snatched by aircraft during the terminal descent phase. Direct impact probes avoid the complexity of the parachute system and generally protect the payload with a crushable core to protect the payload from the high terminal velocity. The payload must be able to withstand the high deceleration loads in this type of a system.

NASA has successfully tackled the complexity of thermal protection systems for numerous missions to inner and outer planets in our solar system in the past; the knowledge gained has been invaluable but incomplete. In particular, ground test to flight traceability issues are incompletely understood.

An upcoming application of EDL technology is the desire to return small probes (i.e. cubesats and nanosats with payloads on the order of 1 kg) from low earth orbit. These missions will generally be launched as secondary payloads on much larger mass missions, or may be used to return biological samples from the International Space Station (ISS).

We are interested in building an integrated approach of probes or small platforms of probes with a spacecraft and a de-orbit system for multiple purposes: (1) As a TPS testbed wherein different TPS materials may be characterized during an actual re-entry, (2) Space/Bio Science mission including space station sample return, (3) materials in space testing such as exposure to space radiation and (4) Instrumentation packaging and demo (earth demo for planetary entry) and this may include such things as TPS instrumentation.

Areas of expertise are sought in all aspects of EDL design for these small entry probes as well as spacecraft integration with small probes that includes novel ideas for de-orbiting small probes. Advances in Multidisciplinary Design Optimization (MDO) are sought specifically in application to address combined aerothermal environments, material response, vehicle thermal-structural performance, payload thermal control, vehicle shape, vehicle size, aerodynamic stability, mass, vehicle entry trajectory/GN&C, and landing systems, characterizing the entry vehicle design problem.

The expected Technology readiness level is 4.

T1.02 Information Technologies for Intelligent Planetary Robotics

Lead Center: ARC

The objective of this subtopic is to develop information technologies that enable planetary robots to better support human exploration. Since February 2004, NASA has been actively engaged in a long-term program to explore the Moon, Mars, and other destinations. Several NASA studies have concluded that extensive and pervasive use of intelligent robots can significantly enhance human exploration, particularly for surface missions that are progressively longer, more complex, and must operate with fewer ground control resources.

Robots can do a variety of work to increase the productivity of human explorers on planetary surfaces. Robots can perform tasks that are highly repetitive, long-duration, or tedious. Robots can perform tasks that help prepare for subsequent crew activity. Robots can perform "follow-up" work, completing tasks started by humans. Example tasks include: robotic recon (advance scouting), systematic site surveys, documenting sites or samples, and unskilled labor (initial site prep, site clean-up, etc.).

Proposals are sought which address the following technology needs:

- Advanced user interfaces for remote robotic exploration, which include Web-based collaboration methods, panoramic and time-lapse imagery, support for public outreach/citizen science, social networking and/or visualization of geospatial information. The primary objectives are to enable more efficient interaction with robots, to facilitate situational awareness, and to enable a broad range of users to participate in robotic exploration.
- Ground control data systems for robotic exploration. Proposals should focus on software tools for planning variable-duration and adjustable autonomy command sequences; for event summarization and notification; for interactively monitoring/replaying task execution; for managing; and/or for automating ground control functions.
- Mobile robot navigation (localization, hazard avoidance, etc.) for multi-km traverses in unstructured environments. Novel "infrastructure free" techniques that utilize passive computer vision (real-time dense stereo, optical flow, etc.), active illumination (e.g., line striping), repurposed flight vehicle sensors (low light imager, star trackers, etc.), and/or wide-area simultaneous localization and mapping (SLAM) are of particular interest.
- Robot software architecture that radically reduces operator workload for remotely operating planetary rovers. This may include: on-board health management and prognostics, on-board automated data triage (to prioritize information for downlink to ground), and learning algorithms to improve hazard detection and selection of locomotion control modes.